Water Quality
Lesson 3
Practice in classroom, Carlsbad Cavern, Other Sites

Water Testing Procedures

Learner Outcomes

The learner will

- Use each of the hydrology instruments correctly.
- Explore the ranges of measurements possible with each instrument.
- Use each instrument as directed in the procedure.
- Understand the importance of quality control.

Background

The key concepts of this lesson are as follows: quality assurance, quality control, reliability, accuracy, procedure and calibration.

Groups of students will rotate among measurement stations for each of the procedures that will be performed in the field by the class. They will practice using the instrument or kit, and the procedure for that particular measurement, exploring sources of variation and error. In the classroom, the students test water samples brought from a variety of places (home, puddles, brooks, other bodies within the state, nation or even from other countries). After experimenting in the classroom, students will collect and test water samples from Carlsbad Cavern and from other nearby caves, using the same procedures.

If enough instruments and kits are available, one might want to focus on a subset of the measurements during a given class period in order to simplify the discussion.

Students should be aware that a quality assurance and quality control plan is necessary to ensure test results are as accurate and precise as possible. Accuracy refers to how close a measurement is to the true value. Precision means the ability to obtain consistent results. Desired accuracy, precision and reliability are ensured by the following:

- Careful calibration, use and maintenance of testing equipment.
- Following the specific directions of a procedure exactly as described.
- Repeating measurements to ensure that they are within acceptable limits.
- Minimizing contamination of samples, stock chemicals and testing equipment.
- Keeping track of samples.

Together these steps help ensure the data collected is valid, valuable and meaningful.

Calibration is a procedure used to check the accuracy of testing equipment. To assure that the equipment is functioning properly, a solution of known value is tested. Calibration procedures vary among the measurements and are detailed in each test.

Safety is always a primary concern. Consult Material Safety Data Sheets (MSDS) that come with kits and buffers. Also consult your local school district's safety procedure guidelines.

Materials

- Supplement numbers 5.4 through 5.15, 5.17
- Refer to individual test procedures for the instruments, equipment and kits required
- One bucket of tap water
- Area map

The following materials will be needed for particular procedures:

- **pH activity**
  samples of vinegar water, distilled water, milk, juice, *Coke*, etc.
- **Temperature activity**
  ice
- **Conductivity activity**
  distilled water, salt
- **Nitrate activity**
  lawn fertilizer

Assessments

- Students will create their own data plots within each group and interpret them in narrative form.
- Each student will keep all data and conclusions in a science portfolio.

Activity #1
Preparation
home, classroom

Procedure

The teacher will

- Ask students to bring in water samples from the home and/or yard.
- Set up measurement stations for each of the six field tests your students will be performing. For each station you will need equipment and instruments to perform the measurement, copies of the activity sheets and one copy of the procedure to be posted at the station.
- Draw a bucket of tap water at the beginning of the day and allow it to sit until class begins. Record the time on a piece of tape attached to the bucket.
- Fill a dissolved oxygen sample bottle at the same time and preserve the sample as directed in field test procedure. Record the time on the sample bottle label.

Activity #2
Station Activities (#1 - #6)
classroom

General Procedures for Each Station

The teacher will

- Divide students into small groups, optimally three per group.
- Checking each other's work, students take turns reading directions, making measurements and recording the data.
- Students rotate through each station learning the instruments and field-test procedures.
- Reconvene the class.
- For each measurement, have students plot all the data points as a way of helping visualize the concept of precision. When measurements are precise, points are close together.
- Discuss the range of measurements found and variations among the measurements.
- Brainstorm with the students why there are discrepancies.
- This is the time to bring up calibration against standards, reliability, accuracy and adherence to field-test procedures. Connect explanations with reasons for specific steps in the procedures.
- Stress the importance of making accurate measurements so they can compare different samples.
- Compare the results they obtained on samples from various places.
- Help them make sense of their results by placing data on a map of the water sources and considering the history of each sample in terms of well water, city water, pool, pond, puddle or brook.
- Stress the importance of accurate measurements when making comparisons. Is the difference real or is there measurement error? Also, this is the time to discuss why we didn't test these samples for dissolved oxygen and temperature and how we might test for them.
- Repeat the above explorations for a further investigative activity, but vary one parameter – such as temperature by cooling one third of each water sample, and heating one third of the water samples, with the remaining one third at room temperature. Compare the effect of water temperature on the other measurements.

Station #1 -- Water Temperature Activity

Time
5 minutes after the thermometer has been calibrated (calibrate every three months)

Learner Outcomes
The learner will
- Use a thermometer correctly.
- Read a scale.
- Record data.

Background
The purpose of this lesson is to learn how to measure the temperature of water samples. The temperature of the water sample is needed for the dissolved oxygen and pH measurements and for studies of global hydrology questions.

Materials
- Alcohol-filled thermometer
- A clock or watch
- Enough string to lower the thermometer into the water
- Rubber band
- Data Sheets

Procedure for Measuring Water Temperature
- Tie one end of a piece of string securely to the end of the thermometer and the other end to a rubber band.
- Slip the rubber band around the wrist so that the thermometer is not lost if it is accidentally dropped into the water.
- Hold the end of the thermometer (opposite the bulb) and shake it several times to remove any air in the enclosed liquid. Note the temperature reading.
- Immerse the thermometer to a depth of 10cm in the sample water for three to five minutes.
- Raise the thermometer only as much as it is necessary to read the temperature.
- Quickly note the temperature reading. If the air temperature is significantly different from the water temperature or it is a windy day, the thermometer reading may change rapidly after it is removed from the water. Try to take the reading while the bulb of the thermometer is still in the water.
- Lower the thermometer for another minute or until it stabilizes. Read it again. If the temperature is unchanged, proceed to the next step.
- Record this temperature along with the date and time on the data sheet.
- Take the average of the temperatures measured by the student groups. If all measured values are within $0.5^{o}C$ of the average, accept the validity of the measurement. Otherwise, repeat the measurement.

Station #2 -- Dissolved Oxygen (DO) Activity

Time
15 minutes for calibration, calibrate every six months; 15 minutes in the field

Learner Outcomes
The learner will
- Use the dissolved oxygen test kit properly.
- Record data.

Background
The purpose of this lesson is to learn how to measure the amount of oxygen dissolved in the water sample. Dissolved oxygen is closely related to survival of plant and animal life in all bodies of water. It is affected by natural processes and by human activities.

Materials
- 250mL bottle
- distilled water
- graduated cylinder

Procedure for Calibration and Quality Control
Calibration should be performed every six months to verify technique and the integrity of chemicals.
- Rinse a 250mL bottle twice with distilled water. Measure 100mL of distilled water with a graduated cylinder.
- Pour this water into the 250mL bottle. Put the lid on tightly and shake it vigorously for 5 minutes.
- Uncap the bottle and take the temperature of the water. Be sure the tip of the thermometer does not touch the bottom or sides of the bottle. Wait one (1) minute before reading the temperature.
- Record the temperature on data sheet.
- Follow directions to measure dissolved oxygen.
- On the data sheet, record the value as mg/L DO for the distilled-water standard. The mg/L DO found using the shaken standard must be within 0.4mg/L of the expected value for a shaken (thus saturated with oxygen) distilled water sample. To find the expected value for a saturated DO distilled water sample:
  - To look up the temperature of your standard in the supplement entitled, Solubility of Oxygen in Water Table.
  - Look up the corresponding solubility of oxygen (mg/L) and record it on the Calibration Data Work Sheet. Example: a standard temperature of 22^{o}C has a corresponding DO solubility of 8.7mg/L.

Sampling Procedure for Measuring Dissolved Oxygen
- Rinse the sampling bottle and hands with sample water three times.
- Rinse sampling bottle three times in distilled water.
- Replace the cap on the bottle.

- Submerge the bottle in sample water and remove the cap.
- Allow the container to fill.
- Tap the bottle to release air bubbles.
- While the bottle is submerged, replace the cap.
- Remove the capped bottle from the water.
- Check to ensure that no bubbles are found, and repeat the sampling procedure.

Procedure for Sample Preservation and Testing

- Use a dissolved oxygen test kit. Follow the instructions carefully. If a scoop is used to measure powdered chemicals, do not allow the scoop to come in contact with the liquid.
- Have students record values on data sheets.
- Have students take the average of the DO values measured by the student groups. If the values are all within 1mg/L of the average, accept measurements as valid. Otherwise, repeat the measurement.
- Put all liquids in waste bottle.

DO test kits involve two overall parts – sample preservation (stabilization) and sample testing. The preservation part involves the addition to the sample of a chemical that precipitates in the presence of dissolved oxygen, followed by addition of a chemical that produces a colored solution. The testing part involves dropwise addition of a *titrant* solution until the color disappears. The DO value is calculated from the volume of titrant added.

Station #3 -- pH Activity

Time
5 minutes for the actual measurements; 10 to 15 minutes in class practice; 5 minutes in the field for actual testing

Learner Outcomes
The learner will
- Use pH measuring equipment.
- Record data.

Background
The purpose of this lesson is to learn how to measure pH. The pH or acidity of the water sample is a key factor in determining what can live in the water.

Materials
- pH pen
- One jewelry screwdriver (for calibration)
- Three 50 or 100mL beakers
- 50mL polyethylene bottle with top
- pH buffer solution for pH 7

or
- pH meter
- Five 50 or 100mL beakers
- Three 50mL polyethylene bottles with tops
- Three pH buffer solutions for pH 4, 7 and 10

And for both pen and meter techniques:
- 100mL graduated cylinder
- Paper towels
- Soft tissues
- Distilled water in a squeeze bottle
- Stirring rod or spoon
- Masking tape
- Permanent marker
- Latex gloves and safety goggles

Procedure for Preparation
- Condition the pH pen or pH meter probes according to manufacturer's instructions. Remember to allow enough time (>one hour). Often pH pens and probes last longer if they are kept wet. Set up calibration buffer solutions of known pH in class. Always calibrate the pen and meter before going into the field. Bring tools and materials to the field site, including buffer solutions.

Procedure for Measuring pH Using a Pen or Meter

In order to measure the pH of any water sample using the pH meter you need to:

- Prepare buffer solutions.
- Calibrate the instruments.
- Recheck your instruments when in the field by measuring buffers.
- Measure the pH of your sample in the field.

Procedure for Calibration

- Calibration should be performed before each set of measurements. This procedure can be performed in the classroom before going to the field.

Procedure for Preparing the Buffer Solutions

- Pre-mixed buffer solutions can be stored for one year, as long as they have not been contaminated. If you are using the powdered pillow buffer, then dissolve it in distilled water as described below. If you are using pre-mixed buffer solutions, measure 50mL into a graduated cylinder and proceed to the *Procedure for Measuring pH*.

Procedure for Each pH Buffer (4, 7 and 10)

- Write the buffer pH and date on two pieces of masking tape. Place one on a clean, dry 100mL beaker and the other on a 50mL bottle.
- Using a graduated cylinder, measure 50mL of distilled water and pour it into the beaker.
- Over the beaker, completely cut open one end of a pillow of buffer powder, then squeeze and shake the pillow to release the powder into the water. Make sure all the powder is released into the water. Stir with stirring rod or spoon until all the powder dissolves.
- Pour the buffer solution into the labeled bottle. Cap the bottle tightly. Discard after a month.
- Continue preparing the other buffers repeating the proceeding steps for each.

Procedure for Calibration of the pH Pen

If the pH pen does not have automatic temperature compensation, the buffer solution should be at 25^{o}C.

- Condition the electrode as described by the manufacturer.
- Rinse the electrode (glass probe) and the area around it twice with distilled water using a squeeze bottle and blot dry with a soft tissue after each rinse. Rinse into a discard beaker or sink, not into the pH buffer solution and do not touch the electrode with your fingers.
- Turn the pen on with the switch on top, then immerse the electrode entirely in the pH 7.0 buffer solution.
- Gently stir the buffer solution with the probe and wait for the reading to stabilize.
- Use a jewelry screwdriver to turn the small screw in the hole in the back of the pen until the reading is exactly 7.0.
- Remove the pH pen from the solution and rinse the electrode with distilled water.
- Pour the buffer solution back into its labeled bottle and seal tightly.

Procedure for Calibration of the pH Meter

- Condition the electrode (probe) as described in the manufacturer's instructions.
- Rinse the electrode (glass probe) and area around it twice with distilled water using a squeeze bottle and blot dry with a soft tissue after each rinse. Rinse into a discard beaker or sink, not into the pH buffer solution and do not touch the electrode with your fingers.
- Turn the meter on (by pressing On/Off button). Push the CAL button to indicate that you will be calibrating the instrument.
- Immerse the electrode in the pH 7.0 buffer solution, making sure that the electrode is entirely immersed. Do not immerse the instrument further than is necessary.
- Gently stir the buffer solution with the electrode and wait for the display value to stabilize. Once the reading has stabilized, press the HOLD/CON button to accept the value and complete the calibration. If the electrode is still immersed in the buffer, the display will read the same value as the pH of the buffer (i.e., 4, 7or 10).
- Remove the pH tester from the buffer solution, rinse the electrode with distilled water, and blot dry with soft tissue.
- Repeat steps 3 through 6 using the pH 4 buffer and then using the pH 10 buffer.
- Set the tester aside on a paper towel and turn the meter off by pushing the On/Off button.
- <u>Pour the buffer solution into their labeled bottles and cap them tightly</u>.

Procedure for Rechecking Your pH Pen or Meter in the Field

- Take the pH buffer solutions into the field with you and treat them as samples. Test the pH of the buffer solutions and record the field pH buffer values on the data sheets. If the values of the buffer solutions are more than + or – 0.2 pH units from the true value, go through the instrument calibration procedure again.
- After you have tested the pen or meter with the buffer solutions, you are ready to measure the pH of the actual water sample.

Procedure for Measuring pH

- Rinse the electrode and the surrounding area with distilled water using the squeeze bottle. Blot the area dry with a soft tissue.
- Fill a clean, dry 100mL beaker to the 50mL line with the water to be tested.
- Immerse the electrode in the water. Be sure that the entire electrode is immersed, but avoid immersing it any further than necessary.
- Stir once and then let display values stabilize.
- Once the display value is stable, read the pH value and record it on the data sheet.
- Repeat the preceding steps for another sample as a quality control check. The two pH values should agree to within 0.2, which is the accuracy of this technique.
- Rinse the probe with distilled water, blot it dry with soft tissue, replace the cap on the probe, and turn the instrument off.
- Students should average pH values measured by the student groups. If the recorded values are all within 0.2, of the average, accept the results as valid. If there is one outlier (a value far different from the rest) discard that value and calculate the average of the other values. If they are all now within 0.2 of this new average, accept the results as valid. If there is a wide scatter in results, discuss the

procedure and the potential sources of error, but do not accept the results. Repeat the procedure if possible to produce a reportable measurement.

Note: pH pen or meter readings may not be accurate if your water sample has a conductivity below 100 microSiemens/cm (pH pens and meters do not function properly below this level).

Station #4 -- Electrical Conductivity Activity

Learner Outcomes
The learner will
- Use a conductivity meter.
- Record data.

Background
The purpose of this lesson is to learn how to measure the conductivity of the water at the sample site. Conductivity is a measure of the amount of total dissolved solids in the water. In advance, the Calibration procedure must be performed and materials must be brought to the water site.

Materials
- Total dissolved solids tester (or conductivity tester)
- Standard Solution
- Distilled water
- Squeeze bottle
- Soft tissue
- Three 50mL or 100mL beakers
- Jewelry screwdriver (for calibration)

Procedure for Calibration
Note: The conductivity meter should be calibrated before each set of measurements. Before use and every six months the temperature compensation should be checked. Calibration standards should be replaced annually.
- The Standard Solution should be tightly capped and kept refrigerated. The label on the bottle in which the solution is stored should include the date on which the solution was made or purchased.
- Remove the cap from the meter.
- Line up two clean and dry 100mL beakers and fill each beaker with just enough Standard Solution to immerse the electrode. *Note: Other standard solutions are available and acceptable. Please calibrate instrument accordingly.*
- Press the On/Off button to turn the tester *on.*
- Rinse the electrode (at the bottom tip of the pen) with distilled water from a squeeze bottle. Do not rinse above the brown line. Blot it dry with a soft tissue.
- Immerse the electrode in the first beaker of standard solution for a second or two. Take the meter out of the first beaker and dip it into the second Standard Solution beaker, without rinsing the electrode.
- Gently stir for a few seconds, then allow the display value to stabilize.
- If the display does not read the standard value, you must adjust the instrument to read this number. Using a small screwdriver, adjust the calibration screw on the pen until the display reads the standard value. Note: Some conductivity meters may have different adjustments.
- Discard the Standard Solution that was used in the two beakers. <u>Do not return the Standard Solution used in this procedure to its original bottle!</u>

- Rinse the electrode with distilled water and blot it dry. Rinse the beakers thoroughly.
- Press the On/Off button to turn the meter off. Cap the meter.

Procedure for Temperature Compensation Check

- The water sample temperature affects conductivity measurements. Your meter should be temperature compensated to give a conductivity reading equivalent to a temperature of 25^oC.
- Measure the conductivity of your standard at 5, 15, 25 and 35^oC. If the conductivity reading is outside the specified range (+/-40 μS/cm) for your standard at 25^oC, then contact the manufacturer.

Procedure for Quality Control in the Field

- Whether the tester is calibrated in the classroom or in the field, the Standard Solution must be tested with the following procedure as if it were a water sample. When tested the standard should read its true value. If it does not, the instrument must be re-calibrated, and the conductivity measurement made again.

Procedure for Measuring Conductivity

- Remove cap from the meter and press the On/Off button to turn the tester on.
- Rinse the electrode with distilled water and blot it dry.
- Fill a clean, dry 100mL beaker with water to be tested.
- Immerse the electrode in the water sample.
- Gently stir the sample for a few seconds, then allow the display value to stabilize.
- Read the display value and record its value on the data sheet.
- Students will take the average of electrical conductivity values measured by the student groups. If the recorded values are all within 40 microSiemens/cm of the average, the results are valid. If you have more than three groups and there is one outlier (a value far different from the rest), discard that value and calculate the average of the other values. If they are now all within 40 microSiemens/cm of this new average, the results are valid. If there is a wide scatter in results, discuss the procedure and the potential sources of error with the students, but do not record the results. Repeat the procedure if possible to produce a reportable measurement.

Station #5 -- Alkalinity Activity

Time
15 minutes

Learner Outcomes
The learner will
- Use the alkalinity test procedure properly.
- Record data.

Background
The purpose of this lesson is to learn how to measure the alkalinity of water samples. Alkalinity is closely related to the kinds of aquatic life that will survive in water. In advance of the field trip, students will need to perform the baking soda standard procedure. Tools and materials need to be brought to field site.

Materials
- Alkalinity test kit
- Baking soda (sodium bicarbonate)
- Distilled water bottle
- Distilled water
- 500mL beaker
- 100mL graduated cylinder
- 500mL graduated cylinder
- Stirring rod
- Data sheets
- Sample bottle
- Latex gloves/safety goggles
- Balance

Procedure for Preparing Baking Soda Standard
- Using a balance, weigh out 1.9g baking soda and add it to a 500mL graduated cylinder.
- Fill the 500mL graduated cylinder to the 500mL mark with distilled water.
- Pour this solution into the 500mL beaker, and stir it with a stirring rod to make sure all of the baking soda has dissolved.
- Pour 15mL from the beaker into the 100mL graduated cylinder.
- Rinse the 500mL graduated cylinder with distilled water first. Pour the 15mL of baking soda solution into the 500mL graduated cylinder.
- Fill the 500mL graduated cylinder to the 500mL mark with distilled water.
- The solution in your 500mL graduated cylinder is the standard.

Note: The true alkalinity of this baking soda standard is 68mg/L as $CaCO_3$. The true value for distilled water is usually below 14mg/L.

Procedure for Quality Control

- Complete the alkalinity procedure below using the baking soda standard in place of a water sample.
- Record the alkalinity value in mg/L as $CaCO_3$, on the Calibration Data Work Sheet.

Procedure for Measuring Alkalinity

- If the alkalinity kit utilized has both a low range protocol and a high range protocol, use the low range protocol, unless the water sample has an alkalinity greater than about 125mg/L as $CaCO_3$. This will allow for more precise measurements.
- Follow the manufacturer's instructions on the alkalinity test kit. The kits are based on the technique of adding a color indicator to the sample and then adding an acid titrant dropwise until a color change is observed.
- Record the total alkalinity in mg/L as $CaCO_3$ on the Data Work Sheet.
- Have students take the average of the alkalinity values measured by all student groups. If the recorded values are all within the equivalent in mg/L of one drop or one gradation of the titrator for the test kit of the average, accept the results as valid. If there are more than three groups and there is one outlier (a value far different from the rest) discard that value and calculate the average of the other values. If values are now all within the equivalent in mg/L of one drop or one gradation of the titrator for the test kit of this new average, accept the results as valid. If there is a wide scatter (more than the equivalent of one drop or one gradation of the titrator) in results, discuss the procedure and the potential sources of error with the students, but do not accept or report the results as valid. Repeat the procedure to produce a reportable measurement.

Station #6 -- Nitrates Activity

Learner Outcomes

The learner will
- Complete a colorimetric analysis.
- Design measurement strategies.
- Record data.

Background

The purpose of this lesson is to obtain nitrate nitrogen measurements of the water at sample sites. Measuring nitrate levels in water is an important step in the determination of water quality. Nitrogen exists in water in numerous forms, two of which are nitrate (NO_3^-) and nitrite (NO_2^-). Of these forms, nitrate is usually the most important. Nitrite can be found in suboxic waters. Nitrate is an essential nutrient for growth of algae and other aquatic plants and can be present at high levels due to inputs from a variety of sources. Nitrate is very difficult to measure directly, so it is reduced to nitrite and the resulting nitrite concentration is measured. The measurement gives the combined concentration of nitrite (if present) and nitrate concentrations. Because we are interested in the nitrate measurement, background levels of nitrite also have to be measured. Nitrate measurements are reported as nitrate nitrogen (mg/L). Nitrite measurements are reported as nitrite nitrogen (mg/L).

Calibration and Quality Control. Standards should be run at least every six months to verify technique and the integrity of chemicals. Fresh standard should be prepared each time, unless the standard has been stabilized. Measuring the standards will help to clarify the instructions in test kits where wording may be unclear.

Note. Test results should be reported as mg/L nitrate nitrogen (NO_3-N; the same units as your standards), and not as mg/L nitrate (NO_3^-).

General Information. To convert mg/L nitrate to mg/L nitrate nitrogen, divide by 4.4 (the ratio of their molecular weights.) For example: 44mg/L NO_3^- is equivalent to 10 mg/L NO_3-N. To convert mg/L nitrite to mg/L nitrite nitrogen divide by 3.3 (the ratio of their molecular weights.)

Materials

- 50mL beaker or flask
- Nitrate Test Kit
- 100mL graduated cylinder
- 500mL graduated cylinder
- 500mL bottles
- Distilled water

Procedures for Preparation (1 class period)

- Read all instructions carefully in the test kit before beginning. Make sure the kit includes all the materials listed. Review proper levels of nitrate that are acceptable in water (10mg/L nitrate-nitrogen for drinking water).

- Discuss why nitrate is important in water.
- Discuss the difference between nitrate nitrogen and nitrate.
- Discuss the difference between nitrate and nitrite.
- Practice by doing calibration.

Procedure for Nitrate Standards (15 minutes)
Nitrate standards do not come with test kits and need to be either ordered separately or prepared as follows:

Stock Nitrate Solution

- Dry KNO_3 (potassium nitrate) in an oven for 24 hours at 105^{o}C.
- Dissolve 3.6g of KNO_3 in distilled water.
- Dilute to 500mL in your 500mL graduated cylinder using distilled water.
- Carefully swirl the solution to mix (do not shake).
- Store in a 500mL bottle. Label with masking tape (include date).
  This makes a 7200mg/L KNO_3 (or a 1000mg/L nitrate nitrogen) solution.

Calculating Nitrate Nitrogen (NO_3-N)

- Take into account the molecular composition of KNO_3 (the ratio of the molecular weight of N to KNO_3 is 0.138): 7200mg/L KNO_3 x 0.138 $\cong$ 1000mg/L nitrate nitrogen (NO_3-N).

Standard Nitrate Solution

- Measure 50mL of the stock nitrate solution using the 100mL graduated cylinder.
- Pour into the 500mL graduated cylinder and dilute to 500mL with distilled water.
- Carefully swirl the solution to mix. The result is a 100mg/L nitrate nitrogen standard.
- Store in a 500mL bottle.
- Label with masking tape (include date).

Make a new stock nitrate solution each time a calibration is conducted if the stock solution has not been preserved. <u>Standard nitrate solutions should be made fresh each time regardless of whether the stock solution has been preserved or not</u>.

Procedure for Quality Control

- Dilute the 100mg/L standard to make a 2mg/L standard. Use this standard to test the accuracy of the nitrate kit.
- Measure out 10mL of the 100mg/L standard nitrate solution using the 100mL graduated cylinder.
- Pour this into the 500mL flask or beaker.
- Measure out 490mL of distilled water in the 500mL graduated cylinder and add to 500mL bottle.
- Label with masking tape (include date).
- Carefully swirl the solution to mix the standard.
- Follow the directions in the *Procedure* section to measure the standard. Where it says *sample water* this is where you use the sample made.

- Record the value of the standard after testing on the Data Work Sheet.
- If the nitrate standard is off by more than 1mg/L, prepare new dilutions and repeat the measurement. If still off, make a new stock solution and repeat the procedure.

Procedure for Measuring Nitrate Nitrogen

- Use a nitrate measurement kit. Rinse the sample tubes in the kit at least three (3) times with sample water before starting the measurement.
- Nitrate nitrogen: Follow the manufacturer's nitrate instructions in the kit. The kits are based on the technique of adding a reagent that reacts with nitrate to form nitrite. The nitrite reacts with a second reagent to form a color. The intensity of the color is proportional to the amount of nitrate in the sample. The concentration is determined by comparing the sample color, after the addition of reagents, to a color comparator included in the kit. If the kit calls for shaking the sample, be sure to shake for the specified period of time. Failure to follow the times specified in the directions will result in inaccurate measurements.
- Have at least three students in the group read the color comparator. Record the nitrate concentration for each student group on the Data Work Sheet. (Note: Hold the comparator up to a light source such as a window, the sky or a lamp. Do not hold it up to the sun.)
- Take the average of the three readings. If the recorded values are all within 1mg/L of the average, record the average on the Data Work Sheet. If they are not within 1mg/L of the average, have the students reread the color comparator, then record and average the new values. (Note: do not reread if more than five minutes has elapsed.) If your remaining values are all now within 1mg/L of the new average, record this new average on the Data Work Sheet. If there is still one outlier (a value far different from the rest) discard that value and calculate a new average of the other values. If there is still wide scatter (more than 1mg/L) in results, discuss the procedure and the potential sources of error with the students, but do not accept a value as valid. Repeat the procedure to produce a valid measurement.
- Nitrite nitrogen: Follow the manufacturer's instructions for nitrite. It is the same procedure, except the reagent to reduce nitrate to nitrite is not used.
- Repeat third and fourth steps to obtain nitrite values.

Activity #3
Water Quality Testing and Monitoring in Carlsbad Cavern
on-going

Procedure

The teacher will

- Arrange field studies at Carlsbad Cavern.
- Ensure that students follow the written study plan and field protocol for collecting samples in Carlsbad Cavern.
- Ensure that all testing procedures performed in Carlsbad Cavern and in the high school chemistry laboratory follow *ASTM Standards* and *Standard Methods for the Examination of Water and Wastewater* and *Hach Water Analysis Handbook*.
- Allow students class time to record all water collection and test data on a spreadsheet for future analyses.